INSTRUCTION MANUAL

DOUBLE PULSE PAIR GENERATOR

MODEL 102-S1

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DATAPULSE

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DOUBLE PULSE PAIR GENERATOR

MODEL 102-S1

Model 102-S1 Pulse Generator offers broad versatility in repetition rate, delay, pulse width, amplitude and pulse shape control. Vernier control of pulse is realized through the use of a 1, 2, 5 range switching arrangement. The vernier control fills-in from 1 to 2, or 2 to 5, or 5 to 10 in a decade switching pattern to give high resolution, but convenient switching.

Three modes of operation are available: Pulse providing a single pulse for each cycle variable in delay from a sync output; Pulse Pair, providing a pair of pulses per cycle variable in separation from each other and with the pair variable in delay from sync output; and Double Pulse Pair, providing a second pulse pair with the same pulse separation as the first, variable in delay from the first pulse pair.

Regulated power supplies insure low jitter and amplitude stability. Electronic overload protection for the output pulse automatically limits the outputs pulse amplitude.

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WARNING

Maximum Repetition Rate for this instrument is 500 kc. Operation above this limit will cause a 20% overload of the +100 Volt Power Supply with resultant decrease in the life of the Series Regulator Tube V21 (6AS7). However if this decrease in tube life can be tolorated, operation may be extended, with some degradation of specifications, to the following duty cycle limits of the main circuitry:

Pulse:	approximately 2 mc
Pulse Pair:	approximately 1 mc
Double Pulse Pair:	approximately 600 kc

SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

1.1.1 Internal:

2 cps to 200 kc in 19 calibrated steps following a 1, 2, 5 pattern. In addition, an uncalibrated vernier control permits pulse repetition rate to be continuously variable from 2 cps to 500 kc.

1.1.2 External:

Requires 20v rms sine wave from 200 cps to 500 kc or positive 20v pulse with rise time less than 0.2 microsec from 0 cps to 500 kc.

1.1.3 Single Pulse:

Momentary-contact push button switch provides one cycle of output for each depression when repetition rate switch in on EXT.

1.1.4 Sync Output:

Positive 20v pulse from less than 100Ω, ac-coupled, approximately 0.1 microsec wide.

1.2 PULSE DELAY

0.5 microsec to 10 millisec in 14 calibrated steps following a 1, 2, 5 pattern. In addition, an uncalibrated vernier control provides delay continuously variable from approximately .20 microsec to 10 millisec.

1.3 MODES OF OPERATION

(Main pulse output on a single line, all pulses with same polarity, amplitude, duration, rise time, and waveform. Mode selectable by front panel switch.)

1.3.1 Pulse:

Occurs once in each sync output cycle.

1.3.2 Pulse Pair:

To occur as a pulse pair in each sync output cycle.

1.3.3 Double Pulse Pair:

To occur as two pulse pairs in each sync output cycle.

1.4 PULSE SEPARATION

(Delay of leading edge of second pulse in each pair with respect to the leading edge of the first pulse.)

0.5 microsec to 10 millisec in 14 calibrated steps following a 1, 2, 5 pattern, with an uncalibrated fill-in control providing continuous control from less than 0.5 microsec to 10 millisec. Pulse separation must not be more than 70% of sync period nor less than 130% of pulse width. Main pulse trailing edge to leading edge separation must be at least 0.3 microsec. In Double Pair operation, pulse separation in the two pairs is the same.

1.5 PAIR SEPARATION

(In double pulse pair mode of operation, the delay of the leading edge of the first pulse in the second pair with respect to the leading edge of the first pulse in the first pair.)

0.5 microsec to 10 millisec in 14 calibrated steps following a 1, 2, 5 pattern, with an uncalibrated fill-in control providing continuous control from less than 0.5 microsec to 10 millisec. Pair separation must not exceed 70% of sync output period. Pair separation must be greater than pulse separation 130% of pulse width or 130% of pulse separation whichever is greater.

1.6 PULSE WIDTH

0.5 microsec to 10 millisec in 14 calibrated steps following a 1, 2, 5 pattern. In addition, an uncalibrated vernier control permits pulse width continuously variable from approximately 0.05 microsec to 10 millisec.

1.7 MAIN PULSE OUTPUT

1.7.1 Polarity:

Selectable either positive or negative with baseline around ground. In addition, a no output position is provided.

1.7.2 Rise Time:

Rise time is continuously variable from approximately 10 nanosec to approximately 0.5 microsec.

1.7.3 Decay Time:

Approximately 10 nanosec with a 50-ohm load. Decay time is affected slightly by the setting of the rise time control.

1.7.4 Amplitude:

Greater than 50 volts delivered into 50 ohms load.

1.7.5 Attenuation at 50Ω Impedance Level:

0 to 60 db in 2-db calibrated steps. In addition, an uncalibrated vernier control permits continuously variable attenuation, 0 to 50 db.

SECTION II

OPERATING INSTRUCTIONS

2.1 CONTROLS AND CONNECTORS

2.1.2 Power-On Switch:

Connects or disconnects ac input voltage to transformer primaries within instrument.

2.1.2 Pilot Lamp:

Lights when power is on.

2.1.3 Repetition Rate:

A 20-position switch which sets the values of R and C in the oscillator to determine pulse repetition frequency. One position is provided for external triggering.

2.1.4 Repetition Rate Vernier:

A potentiometer, concentric with repetition rate switch, provides an uncalibrated fill-in control between positions of repetition rate switch.

2.1.5 Single-Pulse Button:

Momentary-contact, push button switch initiates one cycle of output for each depression when repetition rate switch is on EXT.

2.1.6 Positive External Trigger Input:

BNC connector accepts 20v rms sine wave or 20v pos. pulse, 1 microsec rise 100 cps to 3 mc to externally drive the oscillator when repetition rate switch is on the EXT.

2.1.7 Positive Sync Output:

BNC connector couples a 20v positive sync pulse which provides a "0" time reference for the delay circuit.

2.1.8 Pulse Delay:

A 14-position switch which sets the values of R and C in the delay circuit to determine pulse delay.

2.1.9 Pulse Delay Vernier:

A potentiometer, concentric with pulse delay switch, provides an uncalibrated fill-in between positions of the pulse delay switch.

2.1.10 Mode:

A 3-position switch selects Pulse, Pulse Pair, or Double Pulse Pair mode of operation.

2.1.11 Pulse Separation:

A 14-position switch sets values of R and C to determine pulse separation.

2.1.12 Pulse Separation Vernier:

A potentiometer, concentric with pulse separation switch, provides an uncalibrated fill-in between positions of the pulse separation switch.

2.1.13 Pair Separation:

A 14-position switch sets values of R and C to determine pair separation.

2.1.14 Pair Separation Vernier:

A potentiometer, concentric with pair separation switch, provides an uncalibrated fill-in between positions of the pair separation switch.

2.1.15 Pulse Width:

A 14-position switch which sets the values of R and C in the width circuits to determine pulse width.

2.1.16 Pulse Width Vernier:

A potentiometer, concentric with pulse width switch, provides an uncalibrated fill-in between steps of the pulse width switch.

2.1.17 Polarity:

A 3-position switch selects positive, negative or zero output.

2.1.18 Rise Time:

A potentiometer, mounted concentric with the polarity switch, varies the rise time of the output pulse.

2.1.19 Attenuation 0-10 db Attenuator:

A 6-position switch which selects 0 to 10 db of attenuation in steps of 2 db.

2.1.20 Attenuator Vernier:

A potentiometer, mounted concentric with 0-10 db attenuator, provides an uncalibrated fill-in between steps of the 0-10 db attenuator.

2.1.21 0-50 db:

A 6-position switch which selects 0-50 db of attenuation in 10-db steps.

2.1.22 Pulse Output Connector:

UHF connector couples variable parameter pulse to external load.

2.1.23 Average Pulse Current Overload:

Red indicator indicates maximum average current limitation has been exceeded and overload protection circuit is in operation.

2.1.24 Fuse (Located on Rear Panel):

A 5-amp, fast blow fuse protects instrument against ac overload.

2.1.25 Power Input (Located on Rear Panel):

3-prong male connector connects instrument to ac line through NEMA 3-wire line cord.

2.2 PLACING IN OPERATION

2.2.1 Set PULSE REPETITION RATE to 1 kc; VERNIER ccw.

2.2.2 Set PULSE DELAY to 0.5 microsec; VERNIER cw.

2.2.3 Set Mode switch to PULSE.

2.2.4 Set PULSE WIDTH to 0.5 microsec; VERNIER cw.

2.2.5 Set POLARITY to "+"; RISE TIME ccw.

2.2.6 Terminate output pulse into 50 ohm.

2.2.7 Set POWER switch to ON. Note that pilot lights.

2.2.8 Sync scope from positive sync output. Set scope sweep speed at 0.5 microsec/cm. Set vertical sensitivity at 20v/cm.

2.2.9 View output pulse and verify presence of same.

2.2.10 Allow instrument to warm up 1/2 hour before operating.

SECTION III

THEORY OF OPERATION

3.1 BLOCK DIAGRAM DESCRIPTION OF OPERATION

A pulse repetition rate, variable between 2 cps and 500 kc, is determined by either internal oscillator or an external drive. The output of the oscillator is used to trigger the sync blocking oscillator which provides a "zero time" reference. This pulse is cathode follower coupled-out on a sync pulse and is also used to trigger the delay multivibrator. The gate from the delay multivibrator is differentiated and the lagging edge used to trigger the delay blocking oscillator. The output of the delay multivibrator is then connected to the mode switch (S201).

When the mode switch is on Pulse Operation, the trigger from the delay blocking oscillator is coupled directly to the leading edge blocking oscillator.

When the mode switch is in the Pulse Pair Position, the trigger is coupled to the leading edge blocking oscillator to form the leading edge of Pulse No. 1 and is also used to trigger the pulse separation input blocking oscillator whose output triggers the pulse separation multivibrator. The gate from the pulse separation multivibrator is differentiated and the lagging edge is used to trigger the pulse separation blocking oscillator. The output of the pulse separation blocking oscillator is used to drive the leading edge blocking oscillator a second time to form the leading edge of the second pulse in the pair.

When the mode switch is in the Double Pulse Pair position, the pulse from the delay blocking oscillator is used to trigger the leading edge blocking oscillator to form the first pulse in the first pair and is also used to trigger the pulse separation input blocking oscillator and also the pair separation multivibrator. The output of the pulse separation input blocking oscillator triggers the pulse separation multivibrator.

The gate from the pulse separation multivibrator is differentiated and its lagging edge used to drive the pulse separation blocking oscillator whose output in turn drives the leading edge blocking oscillator to form the leading edge of the second pulse in the first pair.

The gate from the pair separation multivibrator is differentiated and its lagging edge used to trigger the pair separation blocking oscillator whose output triggers the leading edge blocking oscillator to form the leading edge of the first pulse in the second pair. This same pulse retriggers the pulse separation input blocking oscillator, and hence the pulse separation multivibrator whose output drives the pulse separation blocking oscillator, the output of which drives the leading edge blocking oscillator to form the leading edge of the second pulse in the second pair.

The outputs of the leading edge blocking oscillator are in turn used to trigger the width multivibrator and are also delayed 0.09 microsec and amplified by the leading edge amplifiers. The gate from the width multivibrator is differentiated and its lagging edge used to trigger the trailing edge blocking oscillator whose output is amplified by the trailing edge amplifiers. The leading and trailing edge triggers, in conjunction with the duration gate from the width multivibrator, are used to form a fast rise and fall pulse which is applied to the output amplifier and transformed into a heavy current pulse. The pulse from the output amplifier is then applied to the constant impedance attenuator where it is attenuated to the desired level to give the output pulse.

3.2 ASTABLE SCHMITT TRIGGER

The Astable Schmitt trigger circuit differs from a normal Schmitt trigger in that the changing network CT and RT (see Figure 3-1) produces a controlled positive going waveform on the grid (pin 2) of the trigger tube.

This circuit functions as follows: V1B conducts heavily because of the bias imposed upon it by R6, R7, and R10 between B+ and B-. The current of V1B flows through RK causing a large voltage drop which appears as a positive potential at the common cathode pins 3 and 8. As the grid (pin 2) of V1A is around ground, V1A is cut off by the positive potential at its cathode (pin 3). At a time (t), Ct begins to charge through Rt toward B+. This charge continues until time (t2) when the grid-to-cathode-voltage of V1A is small enough to allow conduction. As V1A conducts, its plate (pin 1) dips sharply because of current flowing through R6 (15K). This negative going potential is coupled across R7 (22k) and C3 (27μμf) to the grid of V1B (pin 7). The conduction of V1B now decreases, decreasing the cathode potential of V1A causing V1A to conduct harder and thus regeneratively saturate itself and cut off V1B.

Because R1 is 15k and R8 only 1k, much less current flows through RK as V1B cuts off and its cathode potential approaches ground. The grid of V1A (pin 2) follows the cathode down, discharging Ct through grid current. At a time (t3), a point around ground is reached where the cathode to grid potential is low enough for V1B to conduct. An attendant increase of current through RK causes a higher potential at the cathode of V1A (pin 3). As V1A decreases conduction and its plate (pin 1) becomes more positive, this waveform coupled across R7 and C3 to the grid of V1B (pin 7) causes V1B to conduct harder with an attendant increase of current through RK which regeneratively saturates V1B and cuts off V1A. Ct now begins to charge through Rt toward B+ and the cycle is repeated.

The output of this circuit is taken from the plate of V1B (pin 6) and is used to trigger the Sync Blocking Oscillator (V2)

3.3 BLOCKING OSCILLATOR

The sync blocking oscillator is a typical delay or trailing edge blocking oscillator (see Figure 3-2) and operates as follows:

Initially, both sides of the tube are cut off because of grid bias returns.

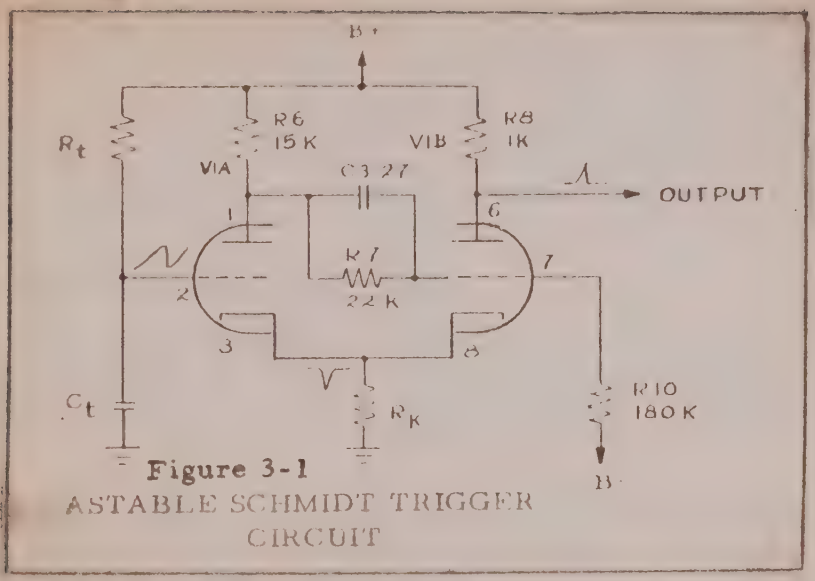
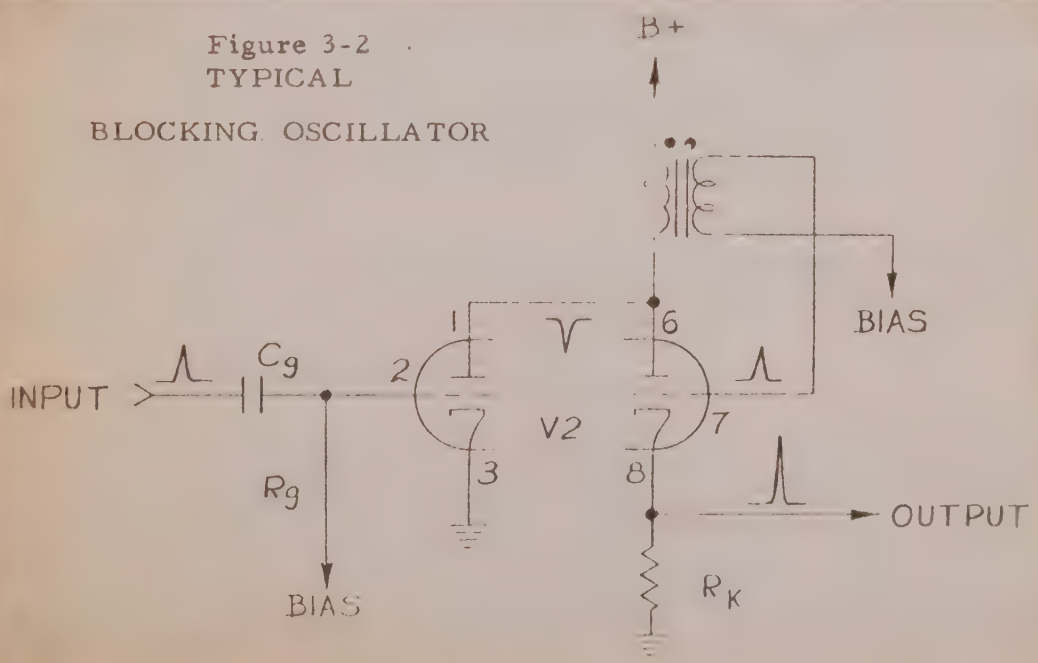


Figure 3-1
ASTABLE SCHMIDT TRIGGER CIRCUIT

Figure 3-2
TYPICAL
BLOCKING OSCILLATOR



When a positive pulse arrives at the grid (pin 2) of the left hand section, conduction is initiated driving both plates negative. Due to the polarity of the transformer a negative pulse upon the plates appears as a positive pulse upon the grid (pin 7) of the right hand side of the tube causing this tube to conduct. This added current drives the plate more negative which in turn reinforces the signal at the grid etc. until the plate (pin 6) of the right hand section is driven into saturation. At this point the gain from grid to plate becomes less than one and the process reverses itself driving the tube into cut off which completes the cycle. The output of this circuit is taken off the cathode (pin 8) of the right hand side across RK.

3.4 ONE-SHOT MULTIVIBRATOR

Pulse delay circuitry is a cathode coupled one shot multivibrator. Since pulse width generation is essentially a delay function, (i.e., the delay of trailing edge with respect to leading edge) the same technique is used to perform both operations. For this reason only delay shall be discussed.

In the quiescent state, V4B is cut off because of the bias imposed upon its grid (pin 7) by the voltage divider composed of R19, R20, R25 and R28. V4A is conducting because of its positive grid return through Rt. As the plate load R19 is great (100k with respect to RK), the common cathodes of V4A and V4B are at a potential around ground. At time (t0) a positive input trigger causes V4B to conduct and because of the low impedance (470Ω) in the plate of V4B (pin 6) a large current flows through RK causing the cathode of V4A (pin 3) to become sufficiently positive to cut off V4A. As the plate (pin 1) of V4A becomes more positive, because of decreased current flow, this waveform is coupled across C9-R20 and C11-R25 to the grid of V4B causing more current to flow, regeneratively saturating V4B. As soon as the cathode of V4B (pin 3) becomes more positive than its grid (pin 2) Ct begins to charge through R5. This charge continues until a point is reached at time (t2) when the grid of V4A (pin 2) is sufficiently positive to allow V2B to again conduct driving its plate (pin 1) negative. This negative waveform coupled across C9-R20 and C11-R25 to the grid of V4B (pin 7) causes conduction of V4B to decrease, forcing the cathode of V4A less positive and increasing conduction, regeneratively saturating V4A and cutting off V4B. The cathodes of V4A and V4B return to their quiescent state and the grid of V4A follows the cathodes down as grid current discharges Ct completing the cycle.

The trailing edge of the negative gate at the plate of V4B (pin 6) is differentiated and used to trigger the delay blocking oscillator. In the case of pulse width, this gate becomes the duration gate.

3.5 TRANSFORMER COUPLED AMPLIFIER

Initially, the tube is cut off because of bias return. As a positive pulse is applied to the grid, the plate conducts heavily and goes negative. The polarity of the transformer is such that a negative charge upon the plate provides a positive going signal to the grid of the next tube. Rp is used to damp the secondary of the transformer to prevent oscillations. Pulse narrowing takes place (see Figure 3-4) as each preceding tube only conducts as the pulse is above the cutoff point thus eliminating the time from baseline to approximately 85% amplitude point.

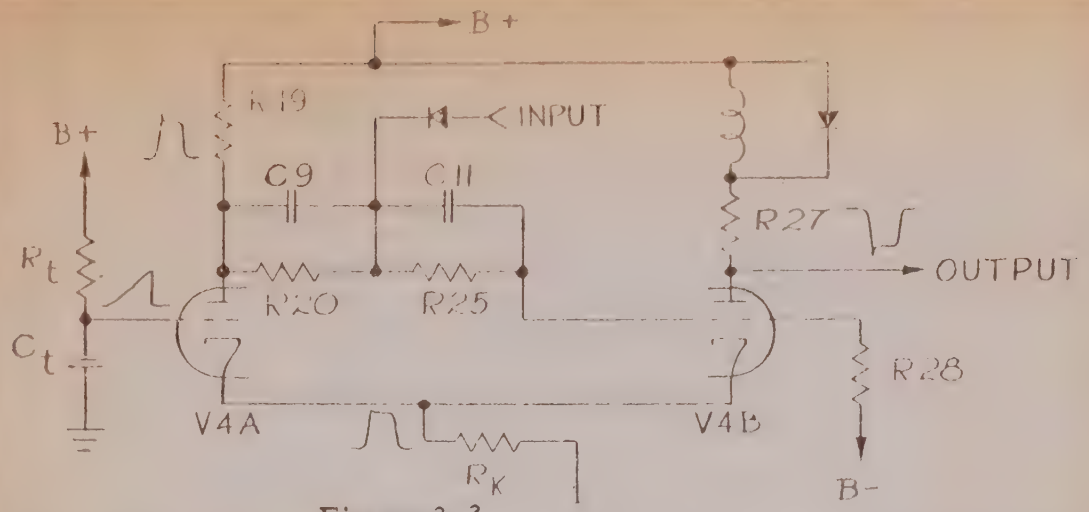
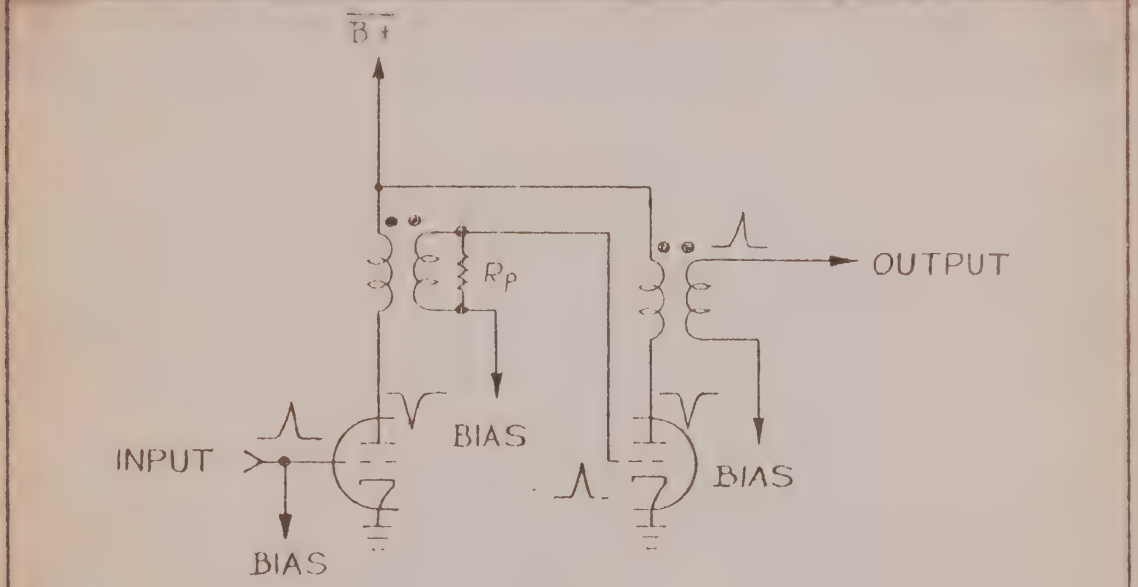


Figure 3-3
CATHODE COUPLED MULTIVIBRATOR



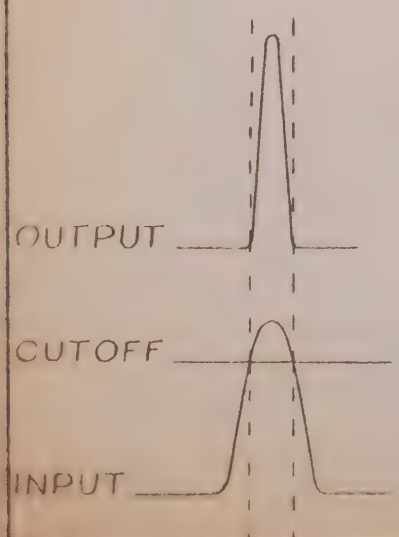


Figure 3-4

TWO STAGES OF
TRIGGER AMPLIFICATION

V14 is normally conducting because of its positive grid return. Its plate (pin 5) sets slightly above ground. The negative duration gate applied at its grid (pin 1) cuts off V14 and its plate starts to rise at a rate governed by circuit capacity. A few nanoseconds later the leading edge trigger is applied to the "lift up diode" (V13) whose low impedance charges the capacitor rapidly causing a fast rise leading edge. The top of the pulse remains at the voltage set by the top slope control as V14 is still held off by the duration gate for the duration of the pulse. The fast rise pulse is applied to the grid (pin 2 and 7) of the cathode follower (V15), whose output drives the output amplifier section. At the end of pulse time, the gate at the grid of V14 subsides and V14 begins to conduct. Simultaneously, the positive trailing edge trigger is applied to the grids (pin 2 and 7) of the trailing edge pull-down tube V12 driving its plate sharply negative discharging circuit capacity and creating a fast fall trailing edge. This fast rise and fall positive pulse is then applied to the output amplifier section. The capacitors C34 (overshoot) and C39 will provide a feedback network to trim pulse irregularities.

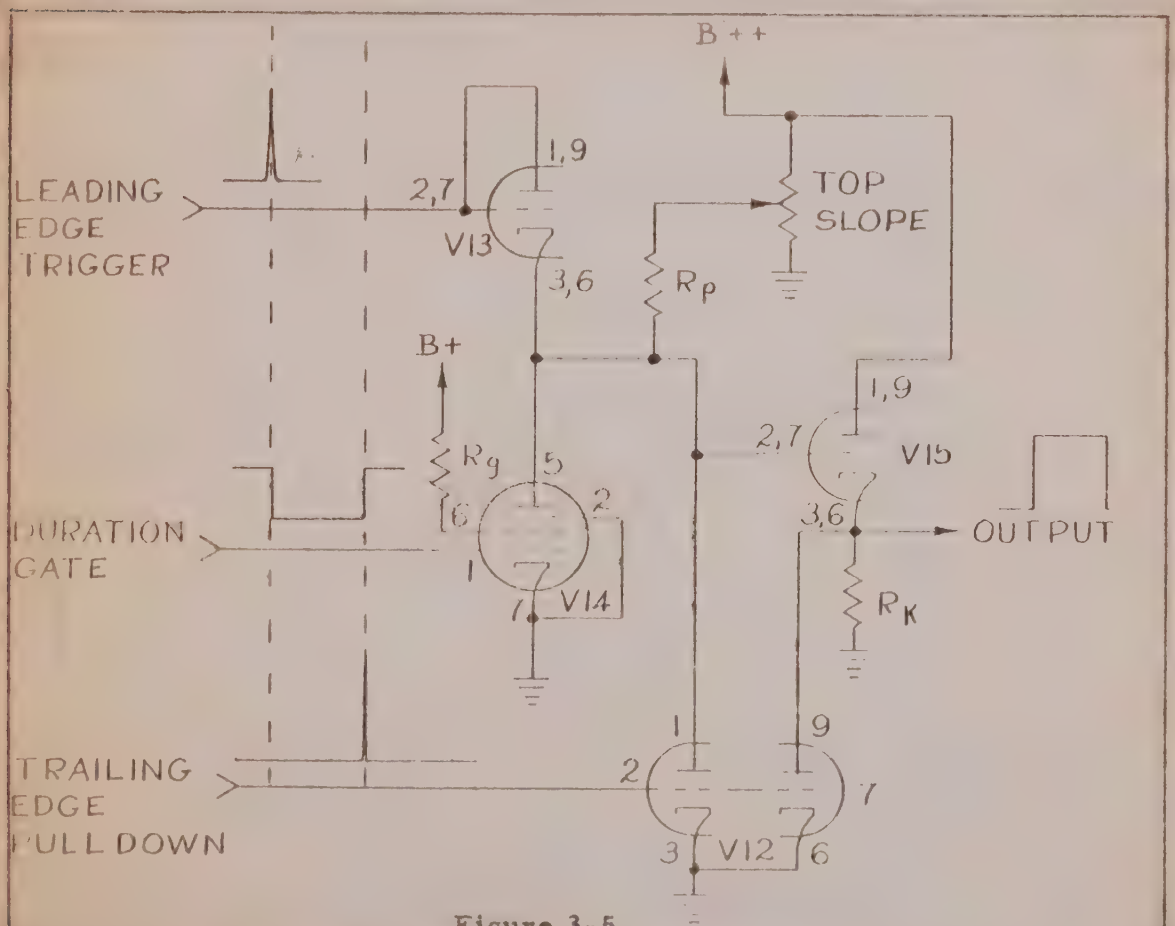


Figure 3-5
SIMPLIFIED PULSE FORMING CIRCUITS

3.7 OUTPUT AMPLIFIER

The fast rise and fall pulse from V15 is coupled across C40 to the rise time control R64. Since no commutation is provided, an increase in the resistance of R64 will cause rise time to be increased in an exponential manner because of the input capacity of the output tubes V17 and V18. The output tubes are connected such that, through boot strappings the screen to cathode voltage and hence screen to control grid voltage remains relatively constant with resultant increase in gm yielding a greater degree of wave shape preservation from input to output.

Positive output pulses are obtained from cathode followers with base line around ground potential. As polarity is changed to negative, the output tube configuration is changed to operate the output tubes as amplifiers, with output taken at the plate. In addition, the ground reference for the power supply is switched such that the base line remains around ground.

Bias is provided through a cathode follower whose low impedance discharges C40 effectively to prevent a bias shift with changes in duty cycle.

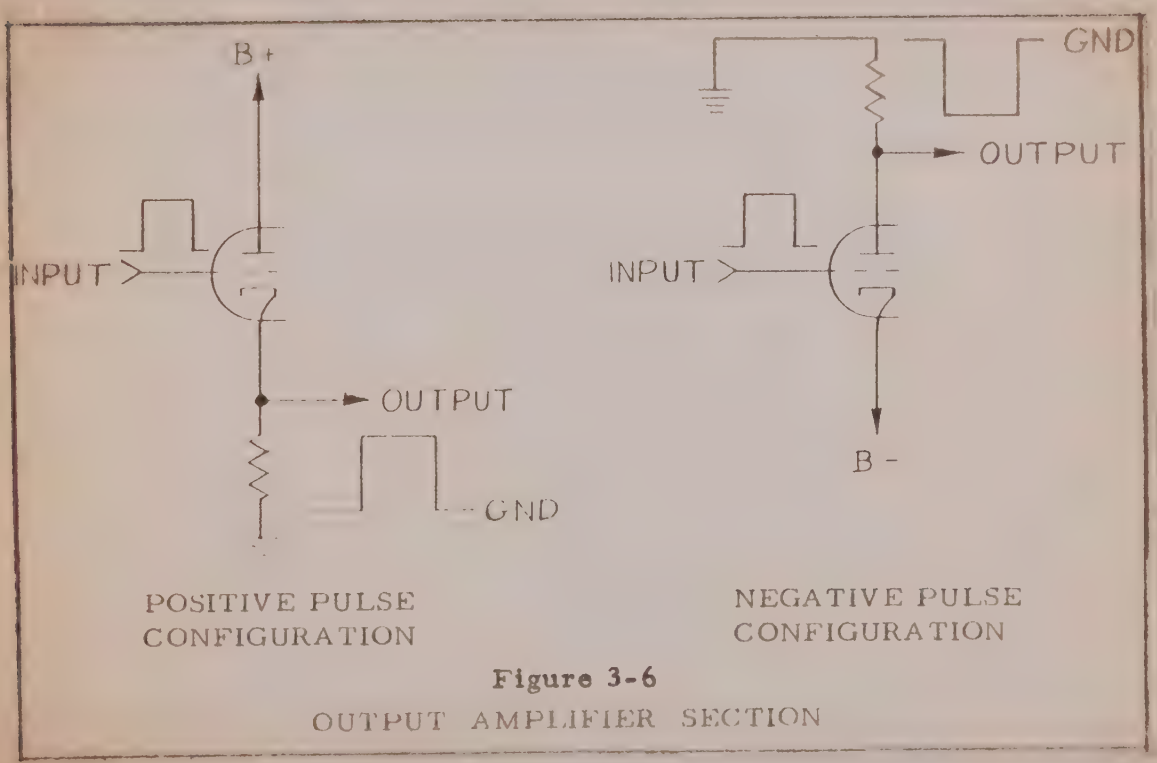


Figure 3-6

OUTPUT AMPLIFIER SECTION

3.8 OVERLOAD PROTECTION CIRCUIT

An overload protection circuit is employed to insure that output current does not exceed a safe value. In the event that this limitation is inadvertently exceeded by control settings, a red warning light glows to indicate that this circuit is in operation.

Output current is sampled through R102 and T2 located in the center tap of the output voltage transformer winding. This sample is rectified by CR9 and filtered by the integrating action of V24A and appears as a dc voltage upon the control grid of V24A as current rises to a point predetermined by the setting of R135. V24A will conduct heavily enough to drop the voltage at its plate (pin 1) appreciably. This negative potential is coupled through R140 to the grid (pin 9) of V22A causing V22A to cutoff. The plate (pin 1) of V22A then rises causing a rise at the control grid (pin 2) of V22B. V22B now conducts heavily pulling down the grid of the +225 supply limiting the output of the +225 supply to approximately 150v. This lowered supply to the pulse forming circuit causes sufficient reduction of the amplitude of the output pulse to hold output current at a safe value. The plate of V24A is also coupled to the grid of V3B. As the plate of V24A drops, the grid of V3B drops cutting off V3B. Connected is parallel with V3B is an Ne2 (overloading indicator) which lights as the plate of V3B goes sufficiently positive.

By setting R136, the indicator is caused to light slightly before the +225v supply is reduced.

Note, that as the gain of the servo loop is greater than one, the output voltage may "cycle" somewhat as the circuit is in operation. Because of this, the instrument should not be operated in overload condition as erroneous readings will result.

As duty cycle is reduced and output current decreases, the circuit settles back to the quiescent state and normal operation ensues.

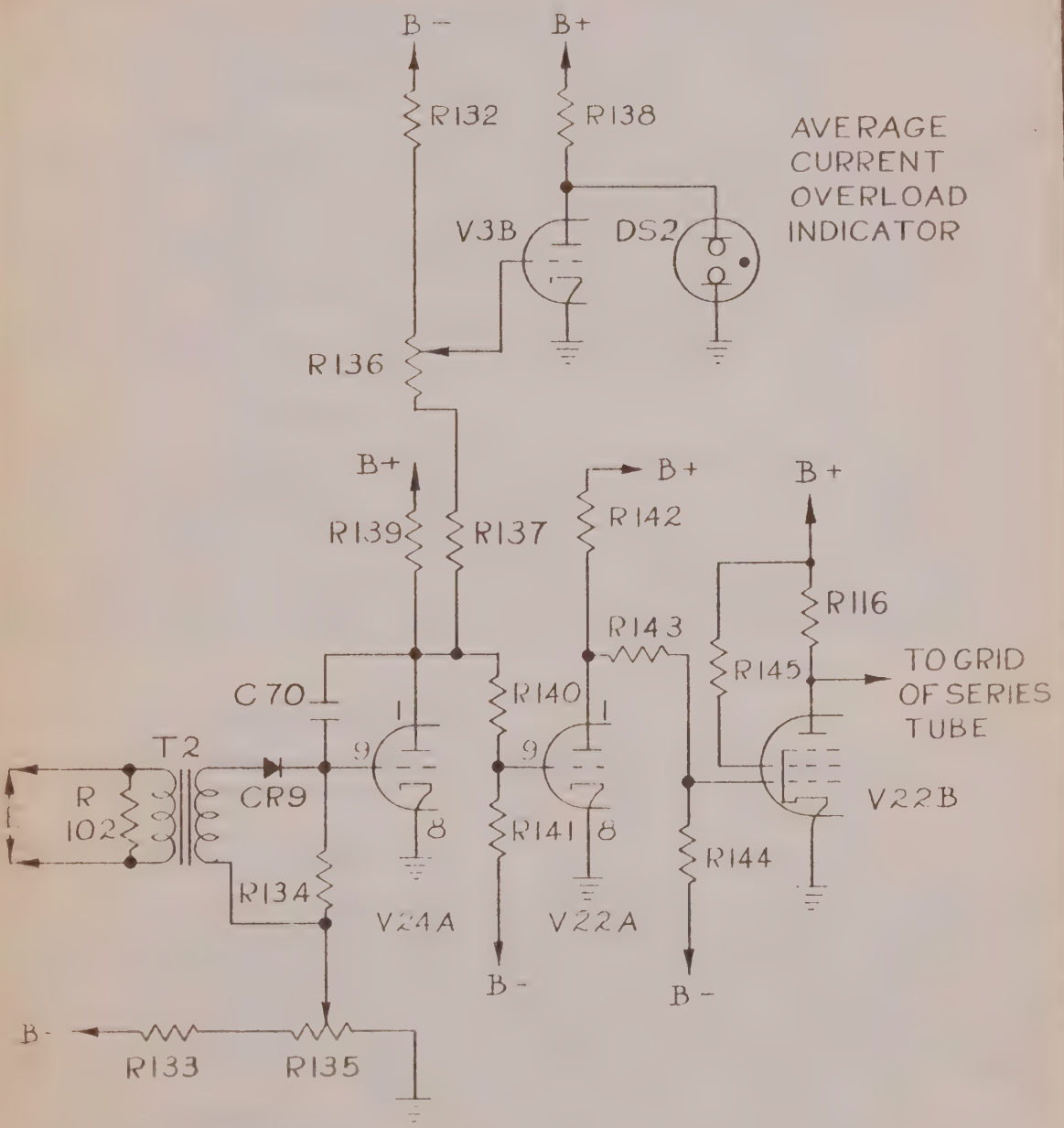


Figure 3-7

OVERLOAD PROTECTION CIRCUIT

SECTION IV

MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE

4.1.1 Preventive Inspection and Service:

Regular inspection and service of a preventive nature will result in optimum performance and longer life of this instrument. Dust covers should be removed at regularly scheduled intervals to permit inspection for dust, tarnish, corrosion, loose nuts and bolts (especially those serving as electrical conductors), loose cables and fuses, charred insulation, scorched resistors and broken wiring. Discoloration of the printed circuit board, due to heat, does not affect the board's electrical properties and may be disregarded in most cases. This problem may be alleviated if the air filters are cleaned frequently and thoroughly as described below.

4.1.2 Filter Cleaning:

The instrument is cooled by air drawn into the interior through a washable aluminum-mesh, adhesive coated filter. When dirty, the filter will restrict the flow of cooling air and cause overheating. To clean the filter, first rap it gently on a hard surface to remove loose dirt. Then wash the filter with hot water and soap. DO NOT USE CAUSTICS. After rinsing and drying, dip or spray the filter with an approved adhesive, such as FILTER-COAT manufactured by the Research Products Corporation of Madison, Wisconsin.

4.1.3 Fan Motor Lubrication:

The fan motor should be lubricated at regular intervals with a few drops of light machine oil.

4.1.4 Minor Repairs:

The operator should be thoroughly acquainted with the instrument's circuit theory and component location before attempting repair. In all cases, setting and adjustment of controls should be checked in order to verify that difficulties encountered are actually caused by malfunction and not by operation outside of specifications. Check tubes and transistors in suspected circuits prior to conducting extensive tests on other components. A check of the important waveforms brought out to the front panel will be of great assistance.

4.1.5 Recalibration:

This instrument was designed to provide maximum reliability and stability. To insure that accuracy remains within stated limits, we suggest that calibration be checked after every 200 hours of operation. If the unit is used intermittently, calibration should be checked every three months. Complete instructions for calibration are given in this manual.

4.2 PARTS REMOVAL AND REPLACEMENT

4.2.1 General:

This instrument is sturdily built and easily accessible. Removal of most parts is so simple that explanations are unnecessary. However, some parts are more easily removed if a definite procedure is followed. Replacement of some parts will also require partial recalibration. Refer to Section 4.4 of this manual for calibration instructions.

4.2.2 Replacement of Switches:

The output amplifier switches may be ordered from DATAPULSE as single sections or as unwired assemblies. If a single wafer on the oscillator, delay, or width switch is defective, the entire switch must be replaced. These are available from our factory either wired or unwired.

The capacitors mounted to these switches are matched sets. Should a capacitor require replacing, its entire set (as indicated on the schematic) must be replaced with a new matched set. These matched condenser sets are available from DATAPULSE. Recalibration is required if the switches or the condenser are replaced.

4.2.3 Replacing Tubes:

Tubes should not be replaced unless they are actually causing trouble. Unnecessary replacement only necessitates recalibration. Tubes removed for maintenance reasons should be returned to the socket from which they were removed unless found to be defective. When replacement is necessary, only high quality tubes should be used.

4.2.4 Soldering Considerations:

Although printed wiring is quite vulnerable to heat excesses, a great deal of resoldering can be done on a single joint if care is taken. A 35 watt wedge tip or pointed tip iron and 60-40 rosin core solder are quite effective. Where both sides of the board are accessible apply the tip of the iron (on the side opposite the component) directly to the solder fillet and pull gently on the pigtail with pliers from the opposite side. Where both sides of the circuit board are not accessible, the component lead will be fed through the board through an eyelet. Apply the iron tip to the eyelet and pull the pigtail out with the pliers. To insert a new component, clean out the hole with a sharp object (it may be necessary to apply more heat) and insert the new component, soldering in the old place.

4.3 CALIBRATION

Prior to attempting calibration, check control settings, check for proper operation and allow the instrument to warm-up for 1/2 hour. Assemble the following.

a. A general purpose 30 mc oscilloscope (TEKTRONIX 543 or equivalent including type "L" high gain preamplifier and Type "N" sampling plug-in or equivalent.)

b. A dc voltmeter (SIMPSON 260 or equivalent). (If overload circuit is to be calibrated, two will be required.)

c. An insulated low capacity screwdriver.

d. A variable ac source (POWERSTAT Model 116 or equivalent).

e. A 50-ohm external termination (DATAPULSE Model 1002 or equivalent).

f. A 500 kc signal generator (HEWLETT-PACKARD 233A or equivalent).

g. If overload circuit is to be calibrated, a tube socket adapter (VECTOR T80C) will be required.

4.3.1 Power Supply Calibration:

NOTE:

As the timing circuits are dependent upon the regulated power supply voltages for reference, any variance of these voltages will necessarily cause a change in calibration accuracy. Therefore, these adjustments should not be attempted unless one is prepared to carry out complete recalibration.

If power supply voltages are found to vary considerably from specified voltage, temporary readjustment may be made; however, bear in mind that measurements made may not be accurate until the instrument has been recalibrated. If any portion of the instrument fails to calibrate, repair should be effected before attempting to complete calibration.

4.3.1.1 -105v (B-) Supply: This voltage is determined within approximately ±10% of -105v and regulated by a gas tube (OB2) and no adjustment is provided. This voltage is used as a reference for the +100v and the +225v power supplies and should, therefore, be checked prior to adjustment of these supplies.

Connect a dc voltmeter from tp8 (-105v) to ground. Vary line voltage with variac ±10% from 115v ac and verify regulation.

4.3.1.2 +110v (B+) Supply:

a. Connect dc voltmeter from tp9 (+110v) to ground. Adjust R130 (+100v adjust) for a reading of 110v.

b. Vary line voltage ±10% around 115v and observe that power supply variation is less than ±2v.

c. Remove voltmeter and connect a high gain oscilloscope from tp9 to ground. Observe that ripple is $\leq$ 50 mv with pulse repetition rate switch on EXT.

4.3.1.3 +225v Supply:

a. Connect dc voltmeter from TP10 (+225v) to ground. Adjust R127 (+225v adjust) for a reading of 225v.

b. Vary line voltage ±10% around 115v and observe that power supply variation is less than ±5v.

c. Remove voltmeter and connect a high gain oscilloscope from TP10 to ground. Observe that ripple is $\leq$ 50 mv with pulse repetition rate switch on EXT.

4.3.1.4 +150 (Floating) Supply:

a. Set pulse REPETITION RATE switch on EXT. Set POLARITY switch in + position.

b. Connect dc voltmeter from TP11 to ground and adjust R100 (+150v adjust) for a reading of 150v.

c. Vary line voltage ±10% around 115v and observe that power supply variation is less than ±5v.

d. Remove voltmeter and connect a high gain oscilloscope from TP11 to ground. Observe that ripple is $\leq$ 50 mv.

4.3.1.5 Bias:

a. Place dc voltmeter from junction of CR22 and C54 to ground. Reading should be -18v, +30%-0%.

b. Place dc voltmeter from junction of R110 and R111 to ground. See that reading is between 5.1-6.2v. Vary line voltage ±10% around 115v. See that reading does not vary more than 1%.

4.3.2 Repetition Rate Calibration

a. Set REPETITION RATE control to 1 kc, VERNIER fully ccw.

Set PULSE DELAY control to 0.5 microsec, VERNIER fully ccw.

Set MODE CONTROL for PULSE

Set PULSE WIDTH control to 0.5 microsec, VERNIER fully cw.

Set POLARITY to "+", ATTENUATOR controls fully cw, RISE TIME fully ccw, terminate pulse output into 50 ohm load (DP #1002).

b. View pulse output on a calibrated sweep oscilloscope. Set R214 (1 kc adjust) for 1 millisec pulse spacing (1 kc).

viewed as ±10% and ±6% respectively.

a. Set REPETITION RATE control to 2 kc, vernier fully ccw.
Set PULSE DELAY control to 0.5 microsec, vernier fully ccw.
Set PULSE WIDTH control to 0.5 microsec, vernier fully cw.
Set POLARITY to +, attenuator controls fully cw, rise time fully ccw, terminate pulse output into 50 ohm load (DP Part No. 1002).

b. View output pulse on calibrated sweep oscilloscope.

e. Set REPETITION RATE control to 5 kc. Adjust R211, "5" adjustment for a pulse spacing of 0.2 millisecond (5kc/s).

g. Set REPETITION RATE control to 10 kc. Adjust R210, "10" adjustment for a pulse spacing of 0.1 millisecond (10 kc/s).

i. Check all ranges from 1 cps to 10 kc/s and insure that they are within ±10%.

j. Set REPETITION RATE control for 50 kc. Adjust R206, 50 kc adjustment for a pulse spacing of 20 microsec. (50 kc/s). Check 20 kc/s and 0.5 mc ranges and insure that they are within ±10%.

k. Set pulse width vernier fully ccw. Set 0.5 mc adjust to cold position.

l. Set REPETITION RATE control to 0.2 mc. Adjust R211, 0.2 mc adjust for a pulse spacing of 5 microsec. (0.2 mc).

j. Set REPETITION RATE control to 0.5 mc. Adjust R202, 0.5 mc adjust for a pulse spacing of 2 microsec. (0.5 mc).

If desired to operate above 500 kc:

k. Set REPETITION RATE control to 1 mc. Adjust R202, 1 mc adjust for a pulse spacing of 1 microsec. (1 mc).

l. Set VERNIER fully ccw. Adjust R201, 2 mc adjust for a pulse spacing of 0.5 microsec. (2 mc).

c. Check oscillator ranges from 0.1 cps to 10 kc and insure that calibration is within ±10%. (It may be necessary to readjust R214 so that all ranges from 2 cps to 10 kc are within ±10%.)

d. Set REPETITION RATE switch to 50 kc. Adjust C206 (50 kc adjust) for a pulse spacing of 20 microsec. (50 kc) Check 20 kc and 0.1 mc ranges -- insure that these are within ±10%.

e. Set PULSE WIDTH VERNIER fully ccw, set REPETITION RATE switch to 0.2 mc, VERNIER fully cw. Adjust C203 for a pulse spacing of 2 microsec (500 kc).

f. Set VERNIER fully ccw. Adjust R201 (0.2 mc Adjust) for a pulse spacing of 5 microsec (200 kc).

g. Set REPETITION RATE switch to EXT. Apply to EXT trigger input jack and 20v rms, 500 kc sine wave and insure that instrument is triggering reliably.

h. Remove sine wave source and depress single pulse push button (PULSE WIDTH set to 10 ms, VERNIER fully cw) observe one cycle of operation.

4.3.3 Pulse Delay Calibration

a. Pulse spacing $\left[\frac{1}{\text{Repetition Rate}}\right]$ should be at least 10 times pulse delay at all times.

b. Set REPETITION RATE switch to 200 cps. VERNIER fully ccw. Set PULSE DELAY switch to 0.5 ms; VERNIER fully cw. Set pulse width to 0.5 microsec; VERNIER fully cw. Set POLARITY to "T" ATTENUATOR fully cw. Set MODE CONTROL to PULSE. View output pulse terminated into 50 ohm.

c. Set R301 (delay adj) for pulse delay of 0.5 ms.

d. Check ranges from 20 microsec to 10 ms and insure that they are within ±10%. (It may be necessary to change the setting of R301 somewhat.)

e. Set PULSE DELAY switch to 5 microsec.

f. Set C302 for 5 microsec pulse delay.

g. Check 10 microsec and 2 microsec ranges and insure that they are within ±10%.

h. Set PULSE DELAY switch to 0.5 microsec.

i. Set C306 for 0.5 microsec pulse delay.

j. Check 1 microsec range and insure that it is within ±10%.

4.3.4 Pulse Width Calibration

a. Pulse spacing $\left[\frac{1}{\text{Repetition Rate}}\right]$ should be at least 10 times pulse width.

b. Set REPETITION RATE switch to 200 cps, VERNIER ccw.
Set PULSE DELAY switch to 0.5 microsec, VERNIER fully cw.
Set MODE CONTROL to PULSE.
Set PULSE WIDTH switch to 0.5 ms, VERNIER fully cw.
Set POLARITY to "+", ATTENUATOR fully cw.
View output pulse terminated into 50 ohm.

c. Set R401 (width adj) for a pulse width of 0.5 ms.

d. Check ranges from 20 microsec to 10 ms and insure that they are within ±10%. (It may be necessary to change the setting of R401 slightly.)

e. Set PULSE WIDTH switch to 5 microsec.

f. Set C402 for a pulse width of 5 microsec.

g. Check 10 microsec and 2 microsec ranges and insure that they are within ±10%.

h. Set PULSE WIDTH switch to 0.5 microsec.

i. Set C406 for a pulse width of 0.5 microsec.

j. Check 1 microsec range and insure that it is within ±10%.

4.3.5 Pulse Separation Calibration

a. Pulse spacing $\left[\frac{1}{\text{Repetition Rate}}\right]$ should be at least 10 times pulse separation at all times.

b. Set REPETITION RATE switch to 200 cps. VERNIER fully ccw.
Set PULSE DELAY switch to 0.5 microsec, VERNIER ccw.
Set MODE switch to PULSE PAIR.
Set PULSE SEPARATION switch to 0.5 ms; VERNIER fully cw. Set PULSE WIDTH to 0.5 microsec; VERNIER fully cw. Set POLARITY to "T", ATTENUATOR fully cw.
View output pulse terminated into 50 ohm.

c. Set R501 (separation adjust) for pulse separation of 0.5 ms.

d. Check ranges from 20 microsec to 10 ms and insure that they are within ±10%. (It may be necessary to change the setting of R501 somewhat.)

e. Set PULSE SEPARATION switch to 5 microsec.

f. Set C502 for 5 microsec pulse separation.

g. Check 10 microsec and 2 microsec ranges and insure that they are within ±10%.

h. Set PULSE SEPARATION switch to 0.5 microsec.

i. Set C506 for 0.5 microsec pulse separation.

j. Check 1 microsec range and insure that it is within ±10%.

4.3.6 Pair Separation Calibration

a. Pulse spacing $\left[\frac{1}{\text{Repetition Rate}}\right]$ should be kept at least 10 times pair separation.

b. Set PULSE REPETITION RATE switch to 200 cps, VERNIER ccw.

Set PULSE DELAY switch to 0.5 microsec, VERNIER fully ccw.

Set MODE switch to DBL PULSE PAIR. Set PULSE SEPARATION switch to 0.5 microsec, VERNIER fully cw. Set PAIR SEPARATION switch to 0.5 microsec, VERNIER fully cw.

Set PULSE WIDTH switch to 0.5, microsec, VERNIER fully ccw.

Set POLARITY to "+", ATTENUATOR controls fully cw.

View output pulse terminated into 50 ohm.

c. Set R601 (pair separation adj) for a pair separation of 0.5 microsec.

d. Check ranges from 20 microsec to 10 ms and insure that they are within ±10%. (It may be necessary to change the setting of R601 slightly).

e. Set pair separation switch to 5 microsec.

f. Set C602 for a pair separation of 5 microsec.

g. Check 10 microsec and 2 microsec ranges and insure that they are within ±10%.

h. Set pair separation switch to 1 microsec.

i. Set C606 for a pair separation of 1 microsec.

4.3.7 Output Waveform

Because the rise of the output waveform is faster than the rated response of most general purpose (30 mc) oscilloscopes, exact observation and rise time measurements may not be made without resorting to either a sampling oscilloscope or traveling wave oscilloscope. Viewing directly on the deflection plates of a slower scope may be used, but it must be kept in mind that there is generally considerable inductance in the deflection plate adapter and the slower sweep speed (20 ns/cm) makes resolution difficult. A general purpose oscilloscope is sufficient for "rough" trimming of output waveform and making top slope adjustment for wide pulses.

a. Set REPETITION RATE control to EXT, VERNIER fully ccw, set PULSE DELAY to 0.5 microsec, VERNIER fully cw, set MODE CONTROL to pulse, set pulse width to 1 ms, VERNIER fully cw. Set POLARITY to "+", attenuators for 0 db. Terminate output pulse into 50-ohm load. Observe output on 0.5v/cm vertical scale.

b. Set (R90) (Pos Bias) for a base line $\leq$ 0.5v above ground.

c. Set POLARITY control to "-", adjust R88 (Neg Bias) for a base line $\leq$ 5 mv below ground.

d. Set POLARITY control to "+". Set REPETITION RATE to 0.1 kc. Set RISE TIME fully ccw. Adjust R60 (top slope) for min. top slope. Adjust C39 (roll) for min. top slope following leading edge approximately 5 microsec.

e. Set pulse width to 1 microsec, set REPETITION RATE to 10 kc. Adjust C34 (overshoot) for squarest leading edge with minimum overshoot.

f. Repeat steps 4 and 5 until further adjustment is unnecessary.

g. Fine adjustment of C34 (overshoot) and R88, R90 (output bias) may be made on fast response oscilloscope. Rise time control may be turned slightly cw to help trim any ringing on leading edge. At this point check that both rise and decay times are $\leq$ 10 ns.

h. Because of the wide variation of all controls some combinations of settings may be found that will cause slight oscillations on the flat top. Slight alteration of any control will usually eliminate this condition.

4.3.8 Duty Cycle Overload

WARNING

THIS ADJUSTMENT IS MADE AND SEALED AT THE FACTORY. ANY ALTERATION OF THIS ADJUSTMENT WILL RESULT IN THE LOSS OF WARRANTY AND MAY RESULT IN SERIOUS DAMAGE TO THE INSTRUMENT.

a. Remove V27. With an adapter such as Vector T80C, reinsert V27 with an ammeter in the plate circuit. (Note: The two halves of V27 are paralleled. Care must be taken that both halves are connected through the ammeter.) Connect a dc voltmeter from the +225v test point (TP10) to ground.

b. Set pulse REPETITION RATE control to 10 kc, VERNIER mid scale. Set PULSE DELAY to 0.5 microsec. Set PULSE WIDTH to 20 microsec, VERNIER fully ccw.

Set POLARITY to "+", ATTENUATION to 0 db.

Terminate output pulse into 50 ohm.

Energize instrument.

c. Slowly turn PULSE WIDTH VERNIER cw until an ammeter reading of 225 ma is attained.

Adjust R135 (overload adjust) until +225v supply just begins to drop.

d. Turn PULSE WIDTH VERNIER fully cw and insure that ammeter reading does not exceed 240 ma.

e. Turn PULSE WIDTH VERNIER ccw until ammeter reads 220 ma. Note that +225v supply has returned to +225v. Adjust R136 (overload indicator) until average pulse current overload lamp on front panel lights.

f. Turn PULSE WIDTH VERNIER fully ccw. Note that average pulse current overload lamp extinguishes.

g. Turn PULSE WIDTH VERNIER slowly cw. Note that average pulse current overload lamp lights at 220 ma and +225v supply drops at 225 ma. Also note that 240 ma is not exceeded as pulse width vernier is turned fully cw. If these conditions are not met, repeat steps 3 to 7.

4.4 SPECIFICATIONS VERIFICATION

A 1/2 hour warm-up period is required before tests are made. Assemble the following or equivalent equipment:

a. 30-mc oscilloscope (TEKTRONIX 543 and sampling pre-amplifier),

b. Two each dc voltmeter (SIMPSON 260).

c. Tube socket adapter (VECTOR T80C).

d. 50-ohm termination (DATAPULSE Model 1002).

e. 500 kc Signal Generator (HEWLETT-PACKARD)

4.4.1 Power Supply: (Repetition Rate Switch on EXT)

4.4.1.1 -105v Supply: Verify that the voltage from TP8 to ground is -105v ±10%.

4.4.1.2 +110v Supply: Verify that the voltage from TP9 to ground is +10v ± 10%.

4.4.1.3 +225v Supply: Verify that the voltage from TP10 to ground is +225v ±10%.

4.4.1.4 +150v (Variable Reference) Supply: With polarity switch in "+" position, verify that the voltage from TP11 to ground is +150v ±10%.

4.4.1.5 Bias Supply: Verify that the voltage from junction of C54 and R110 to ground is -18v, +30% -0%.

Verify that the voltage from junction of R110 and R111 to ground is between -5.1 and -6.2.

4.4.2 Repetition Rate

Set PULSE DELAY to 0.5 microsec, VERNIER fully cw.

Set MODE to PULSE.

Set PULSE WIDTH to 0.5 microsec, VERNIER fully ccw.

Set POLARITY to "+", RISE TIME fully ccw.

Set ATTENUATORS fully cw, terminate pulse output into 50 ohm.

Sync scope from positive sync pulse output. View pulse output at SWEEP SPEED of 0.1 microsec/cm and with vertical sensitivity of 20v/cm.

See Repetition Rate Settings.

4.4.2
(cont.)

Set PULSE WIDTH to 0.5 microsec.

Set PULSE DELAY to 0.5 microsec.

Set REPETITION RATE, VERNIER fully cw.

Set SWEEP SPEED to 10 microsec/cm.

Expand sweep x 100.

View leading edge of 10th pulse and verify that jitter is less than 0.8 cm (0.8%).

Set REPETITION RATE switch to EXT, VERNIER fully ccw.

Set PULSE WIDTH to 0.5 microsec, VERNIER fully ccw.

Apply 20v rms sine wave at 500 kc to positive external trigger input jack.

Set SWEEP SPEED at 1 microsec/cm.

Verify triggering stability.

Remove sine wave input and apply 20v positive pulse (.1 microsec rise) 3 mc sweep speed .1 microsec/cm.

Verify triggering stability

Remove pulse input.

Set PULSE WIDTH to 10 ms, VERNIER fully cw.

SWEEP SPEED 2 mc/cm.

Depress single pulse push button.

Verify occurrence of single pulse.

Set PULSE WIDTH to 0.5 microsec, VERNIER ccw.

Set PULSE DELAY to 0.5 microsec, VERNIER ccw.

Set PULSE REPETITION RATE to 2 mc, VERNIER cw.

Set SWEEP SPEED to 0.1 microsec/cm.

View sync pulse; verify amplitude is greater than 20v.

Terminate sync into 100 ohm.

Verify that amplitude is greater than 10v.

REPETITION RATE SETTINGS

REPETITION RATE SWITCH	VERNIER	WIDTH	SCOPE SWEEP SPEED	CORRECT SPACINGS	TOLERANCE
0.2 mc	ccw	Min.	0.5μs/cm	2μs(0.5 mc)	±10%
0.2 mc	ccw	Min.	1μs/cm	5μs(0.2 mc)	±10%
0.1 mc	ccw	Min.	2μs/cm	10μs(0.1 mc)	±10%
50 kc	ccw	Min.	5μs/cm	20μs(50 kc)	±10%
20 kc	ccw	1μs	10μs/cm	50μs(20 kc)	±10%
10 kc	ccw	1μs	20μs/cm	100μs(10 kc)	±10%
5 kc	ccw	1μs	50μs/cm	200μs(5 kc)	±10%
2 kc	ccw	1μs	0.1 ms/cm	0.5 ms(2 kc)	±10%
1 kc	ccw	10μs	0.2 ms/cm	1 ms(1 kc)	±10%
0.5 kc	ccw	10μs	0.5 ms/cm	2 ms(0.5 kc)	±10%
0.2 kc	ccw	10μs	1 ms/cm	5 ms(0.2 kc)	±10%
0.1 kc	ccw	0.1 ms	2 ms/cm	10 ms(0.1 kc)	±10%
50 cps	ccw	0.1 ms	5 ms/cm	20 ms(50 cps)	±10%
20 cps	ccw	0.1 ms	10 ms/cm	50 ms(20 cps)	±10%
10 cps	ccw	1 ms	20 ms/cm	100 ms(10 cps)	±10%
10 cps	cw	1 ms	5 ms/cm	Less than 47 ms	---
5 cps	cw	1 ms	10 ms/cm	Less than 95 ms	---
5 cps	ccw	1 ms	50 ms/cm	200ms(5 cps)	±10%
2 cps	ccw	1 ms	0.1sec/cm	0.5sec(2 cps)	±10%
2 cps	cw	1 ms	20 ms/cm	Less than 190 ms	---

4.4.3 Pulse Delay

Set PULSE WIDTH control to 1 microsec, VERNIER fully cw (Min.)

Set MODE to PULSE.

Set POLARITY to "+", RISE TIME fully cw.

Set ATTENUATOR controls fully cw.

Terminate output pulse into 50 ohm.

Sync scope from positive sync output.

View output pulse and sync pulse simultaneously (dual trace)

SWEEP SPEED 0.1 microsec/cm, VERTICAL SENSITIVITY 20v/cm.

Note that delay is measured from the 50% point on leading edge of the sync pulse to the 50% point on the leading edge of the output pulse.

See Pulse Delay Settings.

PULSE DELAY SETTINGS

REPETITION RATE	WIDTH	DELAY SWITCH	VERNIER	SCOPE SWEEP SPEED	CORRECT DELAY ±5%
1 kc	1μs	0.5μs	ccw	0.1μs/cm	Approx. 0.2μs
1 kc	1μs	0.5μs	cw	0.1μs/cm	0.5μs
1 kc	1μs	1μs	cw	0.2μs/cm	1μs
1 kc	1μs	2μs	cw	0.5μs/cm	2μs
1 kc	1μs	5μs	cw	1μs/cm	5μs
1 kc	1μs	10μs	cw	2μs/cm	10μs
1 kc	1μs	20μs	cw	5μs/cm	20μs

PULSE DELAY SETTINGS (cont.)

REPETITION RATE	WIDTH	DELAY SWITCH	VERNIER	SCOPE SWEEP SPEED	CORRECT DELAY ±5%
1 kc	1μs	50μs	cw	10μs/cm	50μs
1 kc	1μs	0.1 ms	cw	20μs/cm	0.1 ms
0.1 kc	1μs	0.2 ms	cw	50μs/cm	0.2 ms
0.1 kc	1μs	0.5 ms	cw	0.1 ms/cm	0.5 ms
0.1 kc	1μs	1 ms	cw	0.2 ms/cm	1 ms
10 cps	0.1 ms	2 ms	cw	0.5 ms/cm	2 ms
10 cps	0.1 ms	2 ms	ccw	0.1 ms/cm	Less than 0.95 ms
10 cps	0.1 ms	5 ms	ccw	0.2 ms/cm	Less than 1.9 ms
10 cps	0.1 ms	5 ms	cw	1 ms/cm	5 ms
10 cps	0.1 ms	10 ms	cw	2 ms/cm	10 ms
10 cps	0.1 ms	10 ms	ccw	0.5 ms/cm	Less than 4.7 ms

Set PULSE REPETITION RATE to 0.1 kc, SWEEP SPEED 2 ms/cm.

Slowly turn PULSE DELAY VERNIER cw and verify that 70% duty cycle can be exceeded without circuit failure.

Set PULSE DELAY to 1 ms, VERNIER fully cw.

Set SWEEP SPEED at 0.2 ms/cm.

Expand sweep x 100 and view leading edge of pulse.

Verify that jitter is less than 1/2 cm (0.05%).

4.4.4 Pulse Width:

Set PULSE DELAY control to 0.5 microsec, VERNIER fully ccw.

Set MODE control to PULSE.

Set POLARITY control to "+", RISE TIME fully ccw.

Set ATTENUATOR controls fully cw.

Terminate output pulse into 50 ohm.

Sync scope from positive sync output.

View output pulse.

SWEEP SPEED 0.1 microsec/cm, VERTICAL SENSITIVITY 20v/cm.

Note that width is measured from the 50% point on the leading edge of the output pulse to the 50% point on the lagging edge of the output pulse.

See Pulse Width Settings.

PULSE WIDTH SETTINGS

REPETITION RATE	PULSE WIDTH SWITCH	PULSE WIDTH VERNIER	SCOPE SWEEP SPEED	CORRECT PULSE WIDTH ± 10%
1 kc	0.5μs	ccw	0.1μs/cm	Approx. 0.5μs
1 kc	0.5μs	cw	0.1μs/cm	0.5μs
1 kc	1μs	cw	0.2μs/cm	1μs
1 kc	2μs	cw	0.5μs/cm	2μs
1 kc	5μs	cw	1μs/cm	5μs
1 kc	10μs	cw	2μs/cm	10μs
1 kc	20μs	cw	5μs/cm	20μs
1 kc	50μs	cw	10μs/cm	50μs
1 kc	0.1 ms	cw	20μs/cm	0.1 ms
0.1 kc	0.2 ms	cw	50μs/cm	0.2 ms
0.1 kc	0.5 ms	cw	0.1 ms/cm	0.5 ms

REPETITION RATE	PULSE WIDTH SWITCH	PULSE WIDTH VERNIER	SCOPE SWEEP SPEED	CORRECT PULSE WIDTH ±10%
0.1 kc	1 ms	cw	0.2 ms/cm	1 ms
10 cps	2 ms	cw	0.5 ms/cm	2 ms
10 cps	2 ms	ccw	0.1 ms/cm	Less than 0.95 ms
10 cps	5 ms	ccw	0.2 ms/cm	Less than 1.9 ms
10 cps	5 ms	cw	1 ms/cm	5 ms
10 cps	10 ms	cw	2 ms/cm	10 ms
10 cps	10 ms	ccw	0.5 ms/cm	Less than 4.7 ms

Set PULSE WIDTH switch to 1 ms, VERNIER fully cw.

Set SWEEP SPEED at 0.2 ms/cm

Expand sweep x 100 and view lagging edge of pulse.

Verify that jitter is less than 1/2 cm (0.05%).

4.4.5 Pulse Separation

Set PULSE DELAY control to 0.5 microsec, VERNIER fully ccw.

Set PULSE WIDTH control to 0.5 microsec, VERNIER fully ccw (Min.).

Set MODE control to PULSE PAIR.

Set POLARITY control to "+", RISE TIME fully ccw.

Set ATTENUATOR controls fully cw.

Terminate output pulse into 50 ohm.

Sync scope from positive sync output.

View output pulse and sync pulse simultaneously (dual trace)

SWEEP SPEED 0.1 microsec/cm, VERTICAL SENSITIVITY 20v/cm.

Note that delay is measured from the 50% point on leading edge of the sync pulse to the 50% point on the leading edge of the output pulse.

See Pulse Delay Settings.

PULSE SEPARATION SETTINGS

REPETITION RATE	WIDTH	SWITCH	VERNIER	SCOPE SWEEP" SPEED	CORRECT SEPARATION ±5%
1 kc	0.05μs	0.5μs	cw	0.1μs/cm	0.5μs
1 kc	0.5μs	1μs	cw	0.2μs/cm	1μs
1 kc	1μs	2μs	cw	0.5μs/cm	2μs
1 kc	1μs	5μs	cw	1μs/cm	5μs
1 kc	1μs	10μs	cw	2μs/cm	10μs
1 kc	1μs	20μs	cw	5μs/cm	20μs
1 kc	1μs	50μs	cw	10μs/cm	50μs
1 kc	1μs	0.1 ms	cw	20μs/cm	0.1 ms
0.1 kc	1μs	0.2 ms	cw	50μs/cm	0.2 ms
0.1 kc	1μs	0.5 ms	cw	0.1 ms/cm	0.5 ms
0.1 kc	1μs	1 ms	cw	0.2 ms/cm	1 ms
10 cps	0.1 ms	2 ms	cw	0.5 ms/cm	2 ms
10 cps	0.1 ms	2 ms	ccw	0.1 ms/cm	Less than 0.95 ms
10 cps	0.1 ms	5 ms	ccw	0.2 ms/cm	Less than 1.9 ms
10 cps	0.1 ms	5 ms	cw	1 ms/cm	5 ms
10 cps	0.1 ms	10 ms	cw	2 ms/cm	10 ms
10 cps	0.1 ms	10 ms	ccw	0.5 ms/cm	Less than 4.7 ms

Set PULSE SEPARATION switch to 1 ms, VERNIER fully cw.

Set SWEEP SPEED at 0.2 ms/cm.

Expand sweep x 100 and view leading edge of pulse No. 2 in cycle.

Verify that jitter is less than 1/2 cm (0.05%).

4.4.6 Pair Separation:

Set PULSE DELAY control to 0.5 microsec, VERNIER fully ccw.

Set MODE switch to DOUBLE PULSE PAIR.

Set PULSE SEPARATION switch to 0.5 microsec, VERNIER fully cw.

Set PULSE WIDTH switch to 0.5 microsec, VERNIER fully ccw.

Set POLARITY control to "+", RISE TIME fully ccw.

Set ATTENUATOR controls fully cw.

Terminate output pulse into 50 ohm.

Sync scope from positive sync output.

View output pulse.

SWEEP SPEED 0.1 microsec/cm, VERTICAL SENSITIVITY 20v/cm.

Note that width is measured from the 50% point on the leading edge of the output pulse to the 50% point on the lagging edge of the output pulse.

See Pulse Width Settings.

PAIR SEPARATION SETTINGS

REPETITION RATE	PAIR SEPARATION SWITCH	PAIR SEPARATION VERNIER	SCOPE SWEEP SPEED	CORRECT PULSE WIDTH ±10%
1 kc	1μs	cw	0.2μs/cm	1μs
1 kc	2μs	cw	0.5μs/cm	2μs
1 kc	5μs	cw	1μs/cm	5μs
1 kc	10μs	cw	2μs/cm	10μs
1 kc	20μs	cw	5μs/cm	20μs
1 kc	50μs	cw	10μs/cm	50μs
1 kc	0.1 ms	cw	20μs/cm	0.1 ms
0.1 kc	0.2 ms	cw	50μs/cm	0.2 ms
0.1 kc	0.5 ms	cw	0.1 ms/cm	0.5 ms
0.1 kc	1 ms	cw	0.2 ms/cm	1 ms
10 cps	2 ms	cw	0.5 ms/cm	2 ms

REPETITION RATE	PAIR SEPARATION SWITCH	VERNIER	SCOPE SWEEP SPEED	CORRECT PULSE WIDTH ±10%
10 cps	2 ms	ccw	0.1 ms/cm	Less than 0.95 ms
10 cps	5 ms	ccw	0.2 ms/cm	Less than 1.9 ms
10 cps	5 ms	cw	1 ms/cm	5 ms
10 cps	10 ms	cw	2 ms/cm	10 ms
10 cps	10 ms	ccw	0.5 ms/cm	Less than 4.7 ms

Set PAIR SEPARATION switch to 1 ms, VERNIER fully cw.

Set SWEEP SPEED at 0.2 ms/cm.

Expand sweep x 100 and view leading edge of pulse No. 3 in cycle.

Verify that jitter is less than 1/2 cm (0.05%).

4.4.7 Output Waveform

a. Set PULSE REPETITION RATE switch to 0.2 mc, VERNIER fully cw.

Set PULSE DELAY to 0.5 microsec, VERNIER fully ccw.

Set MODE control to DBL PULSE PAIR.

PULSE SEPARATION to 0.5 microsec, VERNIER fully cw.

PAIR SEPARATION to 1 microsec, VERNIER fully cw.

Set PULSE WIDTH to 0.5 microsec, VERNIER fully ccw.

Set POLARITY to "+", RISE TIME fully ccw.

Set ATTENUATOR controls fully cw.

Sync scope from positive sync output.

View output pulse terminated into 50 ohm.

SWEEP SPEED 0.1 microsec/cm; VERTICAL SENSITIVITY 20v/cm.

b. Observe that amplitude is equal to or greater than 50v.

c. Set POLARITY to "-".
Observe that amplitude is equal to or greater than 50v.

d. Set POLARITY to "+".

e. Step ATTENUATOR to 10 db in 2 db steps and observe with full amp. 60v.

2 db amplitude is 48v ±10%.
4 db amplitude is 38v ±10%.
6 db amplitude is 30v ±10%.
8 db amplitude is 24v ±10%.
10 db amplitude is 19v ±10%.

f. Return control fully cw.

g. Step ATTENUATOR to 50 db in 10 db steps. Observe.

10 db amplitude is 19v ±10%.
20 db amplitude is 6v ±10%.
30 db amplitude is 1.9v ±10%.
40 db amplitude is 0.6v ±10%.
50 db amplitude is 0.19v ±10%.

h. Return control fully cw.

i. Set REPETITION RATE control to 10 kc, VERNIER fully ccw.

Set PULSE WIDTH to 1 microsec, VERNIER fully cw.

j. Observe overshoot is less than 4% (it may be necessary to trim overshoot somewhat with rise time control).

k. Set RISE TIME control fully cw.

Observe that RISE TIME is greater than 0.5 microsec.

l. Set REPETITION RATE to 50 cps.

Set PULSE WIDTH to 1 ms, SWEEP SPEED 0.2 ms/cm.

m. Observe TOP SLOPE is less than 3%.

n. Set REPETITION RATE to 10 kc

Set PULSE WIDTH to 0.5 microsec, VERNIER fully ccw.

Observe output waveform terminated into 50 ohm on sampling oscilloscope.

o. Observe that rise and decay time are equal to or less than 10 nanosec (from 10% to 90% point on leading edge and lagging edge respectively.

p. De-energize equipment. Using a device such as VECTOR T80C, insert an ammeter in plate circuit of V27 taking care that both halves of tube are connected through the ammeter. Connect a voltmeter from TP10 (+225v) to ground.

q. Energize equipment.

r. Set PULSE REPETITION RATE to 0.1 mc, VERNIER centered.

Set PULSE DELAY to 0.5 microsec, VERNIER fully ccw.

Set PULSE WIDTH to 2 microsec, VERNIER fully ccw.

s. Slowly turn PULSE WIDTH VERNIER cw noting ammeter reading.

Verify that average pulse current overload lamp lights at approximately 220 ma.

t. Continue increasing duty cycle and note that +225v supply decreases in voltage at 225 ma.

u. De-energize equipment and remove ammeter and voltmeter.

VOLTAGE AND RESISTANCE TABLES

PIN	V1 6DJ8 VOLTAGE	RESISTANCE	PIN	V2 6DJ8 VOLTAGE	RESISTANCE
1	+70v	150k	1	+100v	100k
2	Zero	10k	2	-5.6v	5k
3	+25v	780 ohm	3	Zero	Zero
4	Zero	Zero	4	Zero	Zero
5	6.3 vac	Zero	5	6.3 vac	Zero
6	+75v	100k	6	+100v	100k
7	+25	1k	7	-5.6v	400 ohm
8	+25	780 ohm	8	Zero	470 ohm
9	---	---	9	---	---

PIN	V3 6DJ8 VOLTAGE	RESISTANCE	PIN	V4 6DJ8 VOLTAGE	RESISTANCE
1	+10v	130k	1	+2v	200k
2	Zero	200k	2	Zero	∞
3	Zero	Zero	3	Zero	50 ohm
4	6.3 vac	Zero	4	6.3 vac	Zero
5	Zero	Zero	5	Zero	Zero
6	+100v	100k	6	+100v	100k
7	Zero	470 ohm	7	-4v	150k
8	+3v	470 ohm	8	Zero	50 ohm
9	---	---	9	---	---

PIN	V5 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	Zero	Zero
5	6.3 vac	Zero
6	+100v	100k
7	-5.6v	500 ohm
8	0	3 ohm
9	---	---

PIN	V6 6DJ8 VOLTAGE	RESISTANCE
1	+2v	200k
2	Zero	∞
3	Zero	50 ohm
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-4v	150k
8	Zero	50 ohm
9	---	---

PIN	V7 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-5.6v	1k
8	Zero	3 ohm
9	---	---

PIN	V8 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	1.5k
3	Zero	Zero
4	Zero	Zero
5	6.3 vac	Zero
6	+100v	100k
7	-5.6v	1k
8	Zero	Zero
9	Zero	Zero

PIN	V9 7119 VOLTAGE	RESISTANCE
1	+225v	300k
2	-18v	100 ohm
3	Zero	Zero
4	6.3 vac	Zero
5	6.3 vac	Zero
6	Zero	Zero
7	-18v	10 ohm
8	Zero	Zero
9	+225v	300k

PIN	V10 7119 VOLTAGE	RESISTANCE
1	+225v	300k
2	-18v	10 ohm
3	Zero	Zero
4	6.3 vac	Zero
5	6.3 vac	Zero
6	Zero	Zero
7	-18v	10 ohm
8	Zero	Zero
9	+225v	300k

PIN	V11 7119 VOLTAGE	RESISTANCE
1	+225v	300k
2	-18v	10 ohm
3	Zero	Zero
4	6.3 vac	Zero
5	6.3 vac	Zero
6	Zero	Zero
7	-18v	10 ohm
8	Zero	Zero
9	+225v	300k

PIN	V12 7119 VOLTAGE	RESISTANCE
1	+2v	300k
2	-18v	10 ohm
3	Zero	Zero
4	6.3 vac	Zero
5	6.3 vac	Zero
6	Zero	Zero
7	-18v	10 ohm
8	Zero	Zero
9	+12v	10k

PIN	V13 7119 VOLTAGE	RESISTANCE
1	Zero	Zero
2	Zero	Zero
3	+2v	300k
4	6.3 vac	Zero
5	6.3 vac	Zero
6	+2v	300k
7	Zero	Zero
8	Zero	Zero
9	Zero	Zero

PIN	V14 6AU6 VOLTAGE	RESISTANCE
1	Zero	∞
2	Zero	Zero
3	6.3 vac	Zero
4	Zero	Zero
5	+2v	300k
6	+100v	100k
7	Zero	Zero

PIN	V15 7119 VOLTAGE	RESISTANCE
1	+225v	300k
2	+2v	300k
3	+12v	10k
4	6.3 vac	Zero
5	6.3 vac	Zero
6	+12v	10k
7	+2v	300k
8	Zero	Zero
9	+225v	300k

PIN	V16 12BH7 VOLTAGE	RESISTANCE
1	Zero	Zero
2	-40	300k
3	-40v	150k
4	3.15 vac	Zero
5	3.15 vac	Zero
6	+150v	500k
7	+150v	500k
8	+150v	∞
9	3.15 vac	Zero

PIN	V17 6DQ5 VOLTAGE	RESISTANCE
1	-40	150k
2	3.15 vac	Zero
3	Zero	50 ohm
4	+150v	∞
5	-40v	150k
6	Zero	50 ohm
7	3.15 vac	Zero
8	150v	∞
Plate Cap	+150v	500k

PIN	V18 6DQ5 VOLTAGE	RESISTANCE
1	-40v	150k
2	3.15 vac	Zero
3	Zero	50 ohm
4	+150v	∞
5	-40v	150k
6	Zero	50 ohm
7	3.15 vac	Zero
8	+150v	∞
Plate Cap	+150v	500k

PIN	V19 QB2 VOLTAGE	RESISTANCE
1	Zero	Zero
2	-105	3.5k
3	Zero	∞
4	-105	3.5k
5	Zero	Zero
6	Zero	∞
7	-105	3.5k

PIN	V20 6AU6 VOLTAGE	RESISTANCE
1	-30v	200k
2	Zero	Zero
3	6.3 vac	Zero
4	Zero	Zero
5	+75v	1.5m
6	+85v	100k
7	Zero	Zero

PIN	V21 6AS7 VOLTAGE	RESISTANCE
1	+75v	1.5m
2	+200v	100k
3	+100v	100k
4	+75v	1.5m
5	+200v	100k
6	+100v	100k
7	Zero	Zero
8	6.3 vac	Zero

PIN	V22 6U8A VOLTAGE	RESISTANCE
1	+45v	100k
2	-10v	400k
3	+100v	100k
4	6.3 vac	Zero
5	Zero	Zero
6	+150v	1.5m
7	Zero	Zero
8	Zero	Zero
9	Zero	400k

PIN	V23 6AS7 VOLTAGE	RESISTANCE
1	+130v	1.5m
2	+320v	200k
3	+225v	300k
4	+130v	1.5m
5	+320v	200k
6	+225v	300k
7	6.3 vac	Zero
8	Zero	Zero
9	---	---

PIN	V24 6U8A VOLTAGE	RESISTANCE
1	+100v	100k
2	-10v	200k
3	+130v	100k
4	6.3 vac	Zero
5	Zero	Zero
6	+130v	1.5m
7	Zero	Zero
8	Zero	Zero
9	-4v	250k

PIN	V25 OB2 VOLTAGE	RESISTANCE
1	Zero	Zero
2	-105	20k
3	Zero	∞
4	-105	20k
5	Zero	Zero
6	Zero	∞
7	-105	20k

PIN	V26 6AU6 VOLTAGE	RESISTANCE
1	-4v	100k
2	Zero	Zero
3	6.3 vac	Zero
4	Zero	Zero
5	+65v	1.5m
6	+125v	80k
7	Zero	Zero

PIN	V27 6AS7 VOLTAGE	RESISTANCE
1	+65v	1.5m
2	+250v	100k
3	+150v	500k
4	+65v	1.5m
5	+250v	100k
6	+150v	500k
7	Zero	Zero
8	6.3 vac	Zero

PIN	VOLTAGE	RESISTANCE

PIN	V1 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-5.6v	500 ohm
8	Zero	470 ohm
9	Zero	Zero

PIN	V2 6DJ8 VOLTAGE	RESISTANCE
1	+2v	200k
2	Zero	∞
3	Zero	50 ohm
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-4v	150k
8	Zero	50 ohm
9	---	---

PIN	V3 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	5.6 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-5.6v	500 ohm
8	Zero	470 ohm
9	Zero	Zero

PIN	V4 6DJ8 VOLTAGE	RESISTANCE
1	+2v	200k
2	Zero	∞
3	Zero	50 ohm
4	Zero	Zero
5	6.3 vac	Zero
6	+100v	100k
7	-4v	150k
8	Zero	50 ohm
9	---	---

PIN	V5 6DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-5.6v	500 ohm
8	Zero	470 ohm
9	Zero	Zero

PIN	V6 DJ8 VOLTAGE	RESISTANCE
1	+100v	100k
2	-5.6v	3k
3	Zero	Zero
4	6.3 vac	Zero
5	Zero	Zero
6	+100v	100k
7	-5.6v	500 ohm
8	Zero	470 ohm
9	Zero	Zero

INSTRUMENT CERTIFICATION

MODEL 102-S1 SN#_____

Instrument has been aged for 24 hours and fully calibrated prior to this test. _____

REPETITION RATE

Oscillator covers 2 cps to 500 kc _____

Accuracy ±10% _____

No "Holes" in Vernier coverage _____

Jitter ≤ 0.08% _____

EXTERNAL TRIGGER

20v rms Drive required from 200 cps to 500 kc _____

+20 v Pulse Drive required from 0 cps to 500 kc _____

SINGLE PULSE

Each depression of push button provides one cycle of output _____

SYNC PULSE

Amplitude >20v open circuit
>10v into 100 ohm _____

MAIN PULSE DELAY

Delay covers 0.2μs to 10 ms _____

Accuracy ±10% _____

No "Holes" in Vernier Coverage _____

Max. duty cycle ≥ 70% _____

Jitter ≤ 0.05% _____

PULSE SEPARATION

Covers 0.5μs to 10 ms _____

Accuracy ±10% _____

No "Holes" in Vernier Coverage _____

Max. duty cycle ≥ 70% _____

Jitter ≤ 0.05% _____

PAIR SEPARATION

Covers 1μs to 10 ms _____

Accuracy ±10% _____

No "Holes" in Vernier Coverage _____

Max. duty cycle ≥ 70% _____

Jitter ≤ 0.05% _____

MAIN PULSE DURATION

Duration covers 0.05μs to 10 ms _____

Accuracy ±10% _____

No "Holes" in Vernier Coverage _____

Jitter ≤ 0.05% _____

MAIN PULSE OUTPUT

Amplitude ≥ 50v delivered into 50 ohm load
(Positive and negative) _____

Attenuator Accuracy ±10% _____

WAVEFORM

Overshoot variable to ≤ 4% _____

Rise time variable to 0.5μs _____

Top slope variable to ≤ 3% (Less than 1 ms duration) _____

Rise time ≤ 10 nanosec (Pos. & Neg.) _____

Decay time ≤ 10 nanosec (Pos. & Neg.) _____

AVERAGE PULSE CURRENT OVERLOAD

Circuit limits average pulse current at 225 ma _____

Average pulse current overload lamp lights at 200 ma _____

R136 [overload indicator Adj]
and R135 [overload adj] sealed with
red glyptol.

I certify that this instrument meets all of the above specifications and conforms to DATAPULSE Standard 91200-000 for workmanship and appearance.

SIGNED _____
Final Test Inspector

DATE _____

PULSE INSTRUMENT NOTES

Though pulse generators may be analogous to a DC switch causing a transient change of DC level, it is the case in modern high speed systems and circuitry that due consideration must be given to the characteristics of the pulse waveform both in generation and application. It can be shown by Fourier analysis that any non-linear waveform may be represented by an infinite series of sinewave components which may be operated upon in both amplitude and phase by circuit parameters. The resulting waveform will then be the infinite series of these modified sinewaves. This is to say that while pulse measurements are normally made in the time domain there is an interdependent relationship upon the frequency response characteristics of a system and the pulse response of that system.

A general purpose pulse generator comprises 5 distinct sections, namely; repetition rate generator, pulse delay, pulse width, pulse forming, and output. It may be well at this point to examine these functions in detail.

The Repetition Rate Section is composed of:

(1) The internal oscillator. This oscillator developes the basic repetition rate of the instrument and may be calibrated in either pulse spacing or frequency (pulse spacing= $\frac{1}{\text{frequency}}$). Some of the important considerations are frequency range, drift, stability under line voltage fluctuation, and cycle to cycle jitter. The emphasis placed on certain of these criteria will determine the type of oscillator used. Provision may be made to drive the generator from an external source this providing sync with outside phenomenon.

(2) The second portion of the repetition rate generator is the synchronization section which accepts the output of either the internal oscillator or external drive and provides a trigger to the delay unit in conjunction with a system "0" time reference. (delay is measured with respect to this).

(3) In addition a third function may be provided where by a gating control is used such that the train of pulses may be either interruped or initiated during the duration of an external gate.

Pulse Delay Considerations Are:

(1) Delay range and coverage which must be wide enough to cover a variety of applications.

(2) Resolution or precision is generally of a greater importance than accuracy particularly as "setups" requiring a high degree of accuracy are generally made with an oscilloscope and the resetability gained by high resolution is a particular asset.

(3) High duty cycle capability is an important consideration to insure that desired delay settings are available for a given repetition frequency.

(4) Delay jitter constitutes noise in the time domain and should be kept to a minimum.

(5) In pulse advance operation the main pulse is triggered directly and the output of the delay unit provides a reference sync variable in time which effectively advances the main pulse.

(6) Stability is always a major consideration. The generator should be stable not only under conditions of fluxuating line voltage but under varying duty cycle.

Pulse Width:

Pulse width can be termed delay of trailing edge with respect to leading edge and as such essentially the same technique may be used. "Clipping lines" are sometimes used employing the reflections of an improperly terminated delay line to provide width definition, however, these are usually cumbersome, not continuously variable and usually severely restricted in range. "Clipping lines" are generally only used to advantage on pulse widths of 25 nanoseconds or less. As delay circuitry is generally analogous to width circuitry the same relative advantages and disadvantages apply.

Pulse Forming:

A number of pulse forming techniques are employed including flip-flops, overdriven amplifiers, clipping amplifiers and compiex networks to mix leading edge, trailing edge and duration components. The important feature of pulse forming circuitry is control over parameters such as overshoot, top slope, etc.

Output:

Output amplifiers are also varied. However, a few generalizations may be shown.

Output amplifiers are generally driven by positive pulses, acting as cathode followers to provide a positive output and acting as amplifiers (inverters) to provide a negative pulse output.

The output impedance (Zo) of a cathode follower is approximately $\frac{RK}{GMRK+1}$. The output impedance of an amplifier is approximately $\frac{Rp\,RL}{Rp+RL}$.

Given a typical tube such as a 6DQ5 which has an approximate gm=10,000 and Rp=5,000 ; assume RL=RK=1,000 . Substitution gives US for a cathode follower

$$Zo=91 \text{ ohm}$$

for amplifier

$$Zo=980 \text{ ohm}$$

Now let the internal load (RK, RL) increase without bound $RK=RL \to \infty$ substitution gives for a cathode follower

$$Zo=\frac{1}{gm}=100 \text{ ohm}$$

for an amplifier

$$Zo=Rp=5,000 \text{ ohm}$$

From this we see that a cathode follower has an inherently low source impedance (Zo) and as such may be used to drive low impedance cables without an attendant loss of voltage. This provides a good voltage generator.

Amplifiers on the other hand with a relatively high Zo tend to approximate a constant current generator ($Zo \rightarrow \infty$) and as such are particularly well suited to current generator applications such as core switching etc.

A positive going grid waveform tends to draw grid current resulting in high gm.while a negative going grid is always below the cathode resulting in lower gm. For this reason source impedance is generally lower during leading edge time than during decay time giving rise to the tendency of pulses to have a faster rise than decay.

If an excess of grid current is drawn in the search for fast rise, overshoot will occur. The best form of output is achieved when both positive and negative pulses occur with base line at ground. This can be accomplished by arranging the output configuration such that the power supply ground reference is switched as polarity is selected. If pulses are generated at other DC levels than ground then they must necessarily be condenser coupled out on a general purpose generator. This leads to differentiation of wide pulses and base line shifts with changes in duty cycle.

Two methods of amplitude control are predominate, first is varying output bias or the amplitude of the driving waveform.

These methods cause variations in output source impedance and may cause variations in waveform parameters. However, this method reduces the amount of power required from the output stage and allow higher width duty cycles to be available without exceeding maximum average current limitations.

The second method is a constant impedance attenuator. The characteristics of this method are diametrically opposed to the variable bias method in that extreme waveform fidelity is maintained if the load impedance is matched to the attenuator. On the other hand, as the attenuator simply draws power from the load a constant output power is required from the output stage regardless of ultimate amplitude of the output waveform. In short, variable bias conserves output power at the expense of waveform fidelity while a constant impedance attenuator preserves waveform fidelity at the expense of output power.

Average output current is $Ia = \frac{EoD}{Z}$ where Eo is the output pulse voltage; Z is the total load including internal load, attenuator if any, and external load; and D is pulse width duty cycle. For this reason the output power limitation of pulse generators are generally specified as 1. a maximum pulse width duty cycle D given Eo and Z or, 2. a maximum Ia with Eo, D, and Z variable.

PULSE INSTRUMENT NOTES

Low impedance cables are used almost exclusively for the interconnection of the pulse outputs to external loads as they provide shielding and proper ground return for fast rise pulses.

However, shielded cables are transmission lines and must be properly terminated lest they give rise to reflection and possiblity of oscillation. Also to be considered are residual parameters of components, such as lead length, inductive component of wire wound resistors and electrolytic condensers, etc. Even the "non inductive" wire wound resistors exhibit appreciable inductance at the higher frequencies present as leading edge components of fast rise pulses.

Available pulse powers of 50 watts are not uncommon, therefore, careful consideration must be given to the power rating of the load when high pulse width duty cycles are used.

Required source impedance (Z_o) for driving a circuit is given by the equation

$$Z_o = \frac{tr}{2.2C}$$

where tr is the rise time required and C is the input capacity of the circuit driven. From this it is readily apparent that the input admittance of an oscilloscope probe precludes observation of high impedance phenomenon without alterations in both amplitude and rise time.

In the area of oscilloscope observation, one must note the effect of the vertical amplifier response of the oscilloscope upon rise time observation.

$$t_{obs} = \sqrt{t_{in}^2 + t_{scope}^2}$$

gives the relationship of observed rise time, scope rise time and actual rise time. This equation may be written

$$t_{in} = \sqrt{t_{obs}^2 - t_{scope}^2}$$

For example, given vertical amplifier response of 15 nanoseconds and a rise time is observed to be 18 nanoseconds, then the actual rise time

$$t_{in} = \sqrt{18^2 - 15^2}$$

or approximately 10 nanoseconds while an observed 16 nanoseconds would be an actual 5 nanoseconds (twice as fast). It is then apparent that for observations of phenomenon in the region of 10 nanoseconds and less, resolution of most oscilloscopes is not sufficient for actual comparison. Two solutions present themselves. First is the use of a traveling wave oscilloscope or if the phenomena is reoccurring, a sampling

technique. The second is a method of displaying the desired signal directly upon the deflection plates of the oscilloscope. Most manufacturers such as Tektronix, Dumont, and Hewlett-Packard have this feature available.

ABBREVIATIONS & DEFINITIONS

Cer	Ceramic
Comp	Composition
EMC	Electrolytic Metal Case
f	Farad
GMV	Guaranteed minimum value
h	Henry
K	Kilohm or 10^3 ohms
M/ceramic	Mica or ceramic
Meg or M	Megohm or 10^6 ohms
μ	Micro or 10^{-6}
$\mu\mu$	Micromicro or 10^{-12}
M	Milli or 10^{-3}
Ω	Ohm
v	Volt
w	Watt
WW	Wire Wound
Z	Impedance

For further abbreviations see MIL-STD-12B or MIL-STD-16B.

Symbols follow MIL-STD-15A

ABBREVIATIONS & DEFINITIONS

$$\text{Duty Cycle in \%} = \frac{\text{duration of event}}{\text{duration of period}} \times 100$$

Delay is defined from the 50% point on the leading edge of the sync pulse (t=0) to the 50% point on the leading edge of the output pulse.

Pulse width is defined from the 50% point on the leading edge to the corresponding point on the trailing edge of a pulse.

Rise time is the time between the 10% and 90% amplitude levels on the leading edge of a pulse.

Overshoot and ringing; overshoot is a damped oscillation on the leading corner of the pulse, expressed as a % of pulse amplitude. If several cycles of oscillation exist it is referred to as ringing.

Top slope is the amount of sag or droop on the top of a pulse measured as a % of pulse amplitude.

Decay time, sometimes referred to as fall time, is the time between the 90% amplitude point and the 10% amplitude point on the trailing edge of a pulse.

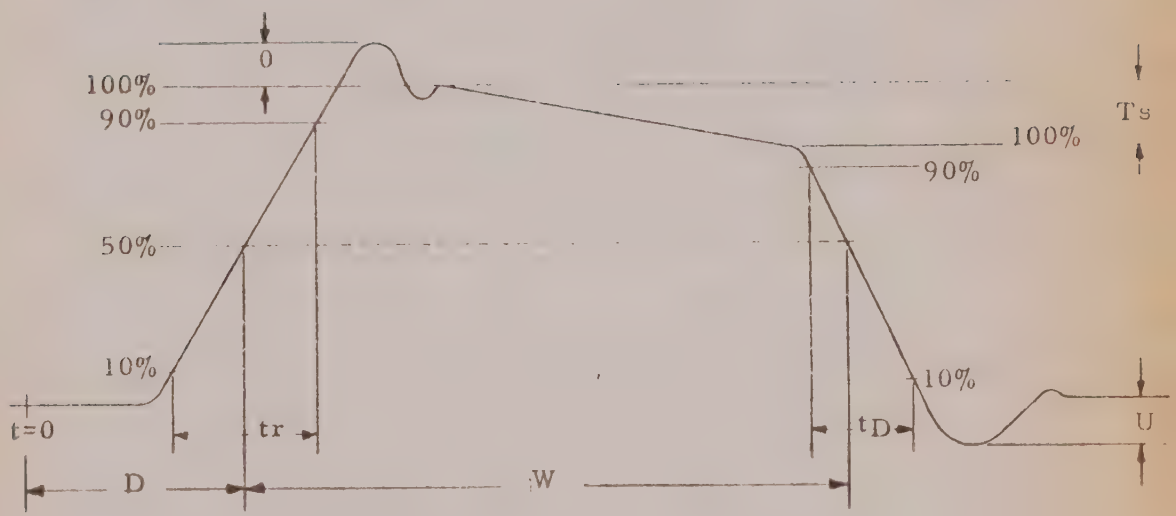
Undershoot is a damped oscillation occurring at the completion of decay time.

Jitter is defined as a variation in time of any pulse parameter from cycle to cycle.

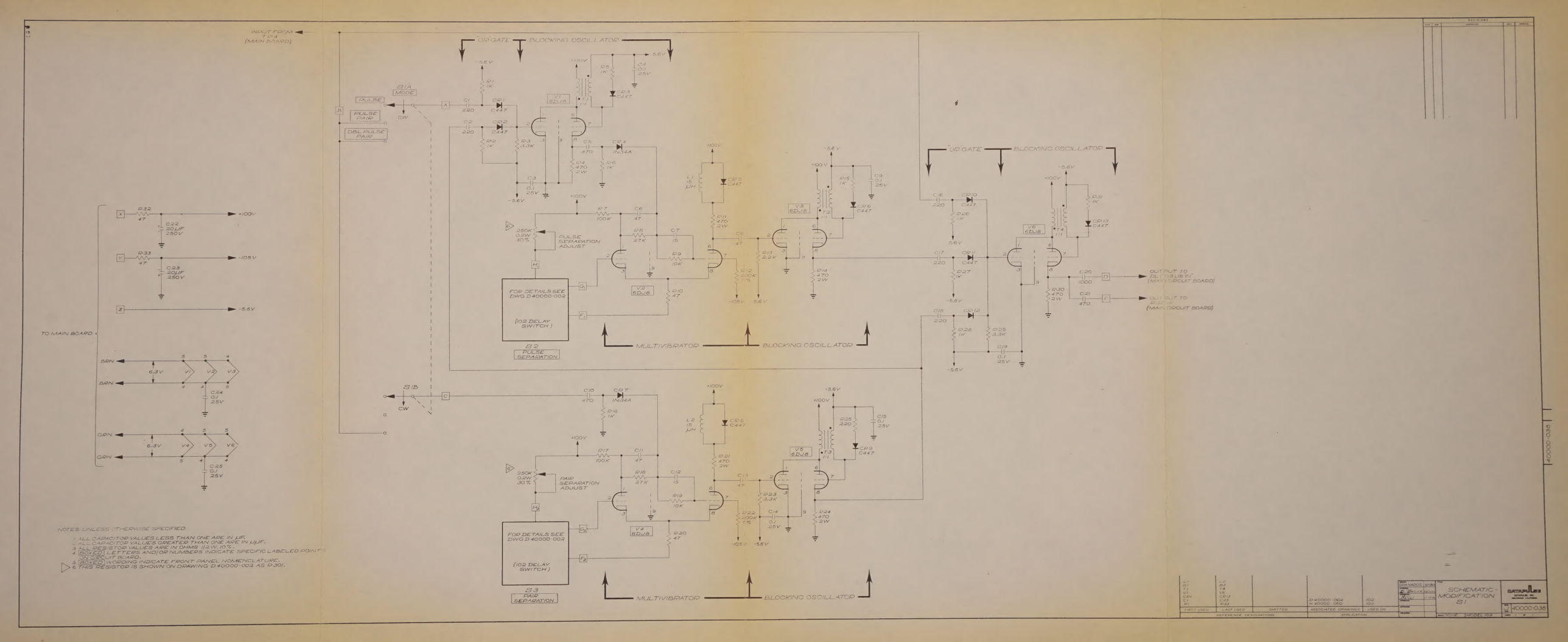
Accuracy - the "closeness" to a given figure which may be obtained.

Precision or Resolution - that smallest increment of a given figure which may be defined.

"Base line around ground" is defined as $-0.5v \leq$ Base line $\leq +0.5v$.



D = Delay
W = Pulse Width
tr = Rise Time
0 = Overshoot
Ts = Top Slope
t_D = Decay time
U = Undershoot


INPUT FROM J D4 (MAIN BOARD)
OR GATE
BLOCKING OSCILLATOR
S1A MODE
PULSE
PULSE PAIR
DBL PULSE PAIR
CW
PULSE SEPARATION ADJUST
FOR DETAILS SEE DWG D40000-002
(102 DELAY SWITCH)
S2 PULSE SEPARATION
MULTIVIBRATOR
BLOCKING OSCILLATOR
S1B
PAIR SEPARATION ADJUST
S3 PAIR SEPARATION
OUTPUT TO D4 (MAIN CIRCUIT BOARD)
TO MAIN BOARD
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF.
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN µµF.
3. ALL RESISTOR VALUES ARE IN OHMS (Ω), W, 10%.
4. (BOXED) LETTERS AND/OR NUMBERS INDICATE SPECIFIC LABELED POINTS ON CIRCUIT BOARD.
5. (BOXED) WIRING INDICATE FRONT PANEL NOMENCLATURE.
6. THIS RESISTOR IS SHOWN ON DRAWING D40000-002 AS R301.
SCHEMATIC - MODIFICATION S1
SAUNDERS
D40000-036

WARRANTY

Datapulse Incorporated warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse Incorporated.

Datapulse Incorporated reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse Incorporated and Datapulse Incorporated neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Datapulse Incorporated instruments.

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